NASA Stennis Space Center, MS
Visitor's Center

LOGANEnergy Corp.

Initial Report NASA Stennis Space Center Demonstration Program
CERL BAA FY'01 PEM Project
Stennis, MS
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Introduction

Fuel Cells convert the chemical energy of a fuel into useable electric and thermal energy without an intermediate combustion or mechanical process. In that respect, they are similar to batteries. However, unlike batteries, fuel cells oxidize externally supplied fuel and therefore do not need recharging. Ever since National Aeronautics and Space Administration (NASA) adopted fuel cell power for the Apollo Space program, American industry has been fascinated by the prospects for their use on earth as well.

When integrated with a fuel processor and a solid-state power conditioner, the fuel cell power system becomes one that produces clean, quiet and reliable electric power and heat. Several manufacturers are currently hard at work to translate the basic technology into consumer products. As advances in PEM technology and mass production converge to introduce competitively costs systems into the marketplace, many are betting that small-scale fuel cell generators will soon be ready to tackle thousands of residential and small-scale commercial power applications. These new appliances will be packaged energy systems providing both heat and electricity that will be able to operate with or without the local utility grid.

Until recently, however, the promise of fuel cell technology has been slow to advance beyond a narrow beachhead commonly referred to as the "early adopter" marketplace. Broader market appeal has been constrained by fits, false starts and premature expectations raised by eager manufacturers; but also high prices, skepticism, and not a little resistance by parochial interests have all restricted the opportunity. Notwithstanding, during the decade of the 1990s, the UTC PC25C Fuel Cell program, assisted by a significant DOD investment, gradually established a solid record of achievement and customer satisfaction at numerous US locations and around the world. Installations sites included military hospitals, commercial buildings, banks, food processing facilities, data processing centers, police stations, and airports.

While many of these "early adopters" hosted pure technology demonstration projects, the industry gained valuable experience and knowledge because of them. More recently, however, customers have warmed to the proposition that fuel cells have real performance advantages in various combined heat and critical power applications (CHP). Perhaps their attitudes and business practices may be adjusting to accommodate an uncertain energy landscape. Clearly, many energy providers are scrambling to maintain their market base, others are floundering, and still others are stalking new opportunity. Nevertheless, they are all discovering that informed consumers have gained new leverage through the power of choice. Increasingly, newspaper articles, periodicals and other media outlets are scoring direct hits with stories about fuel cells. Policy makers are out front raising expectations of a cleaner, highly efficient fuel cell/hydrogen based economy of the future. The signals are clear. Initiative and momentum are driving a rapidly maturing fuel cell industry.

Certainly one reason is because fuel cell technology represents, perhaps, the most exciting and innovative development in the energy industry today. In some ways the technology is maturing more rapidly and markets are developing more quickly than the supporting infrastructure, codes and standards are able to accommodate. However, as technology demonstrations increasingly give way to CHP fuel cell installations that provide practical solutions to demanding consumer requirements, such roadblocks should get resolved as consumer and utility interests find common ground. For example, in most applications, large-scale fuel cell installations may off-load significant power resources during critical grid demand intervals, serving utility interests, while providing "hot" back-up for mission essential loads in commercial and even residential applications. Additionally, they may also provide Btus for heating and cooling loads-demonstrating the dual benefits of enhancing grid stability and promoting energy conservation.

At the small scale and residential end of the fuel cell spectrum, the opportunity is just as promising for the rapid expansion of distributed power generation. Conceivably, thousands of 3kW to 5kW CHP fuel cells in homes and small businesses across the country could within several years displace hundreds of MWhs of electricity and millions of Btus with clean, efficient and reliable energy service. If this occurs, it could have a dramatic impact on both the energy industry, and on the nation's economy and security. Consumers, not utilities, could begin displacing environmentally disruptive generation methods, thereby forcing changes in the industry. As providers of grid resources, they may one day collectively enhance grid stability in many areas, boosting efficiency and conservation norms, and having a decided impact on the evolution of national energy policy.

Against this backdrop, the US Army Corps of Engineers Construction Engineering Research Lab (CERL) has contracted with LOGANEnergy through its FY'01 PEM Demonstration Program to engage a progressive fuel cell energy strategy to inform future DOD policy and planning. Broadly speaking, this engagement directs LOGAN to purchase and install residential and small-scale fuel cell power plants, and then test and evaluate their performance in widespread applications at selected military installations. Three events make this program very timely. They are (a) the complexities and perplexities of utility deregulation juxtaposed with, (b) base utility privatization programs, and (c) the nascent interest in distributed generation / CHP technologies that promise more efficient utilization of resources.

If the fuel cell industry appeared very much ahead of a languid power market in the recent past, today those markets are in comparative turmoil. Prices and availability, in some cases, are volatile and beyond the comprehension of energy managers and consumers alike. Consumers who are seeking innovative and efficient energy solutions for greater comfort, convenience and reliability are adding a new urgency. If the fuel cell industry can capitalize on these conditions, it will have a rich market opportunity, but it will have to deliver energy services and benefits that are immediate, site specific, cost effective, energy efficient, and certifiably green!

In order to test and evaluate the state of PEM fuel cell technology against these challenges, LOGANEnergy Corporation will demonstrate over the course of a year a PEM small-scale fuel cell at NASA Stennis Space Center, MS. The installation will take place at the visitor's facility which is the focal point of the space center. The project will be guided by an operations plan that will direct the installation, testing, evaluation and reporting on the performance of the unit. The objectives of the plan include;

1. Evaluating installation methods in order to help standardize safe and cost effective installation practices,
2. Evaluating "out of the box" reliability and interoperability with existing facility electrical and mechanical systems / infrastructure,
3. Evaluating actual PEM operating characteristics as compared to manufacturer representations,
4. Measuring the cost of operating a PEM unit under real market conditions,
5. Measuring, collecting and analyzing operating data including, total load hours, availability, kW production, fuel consumption, water consumption, forced outages, serviceability, and manufacturer's support.
6. Introducing PEM technology, power distribution and energy efficiency to DOD and local stakeholders in the community.

The project will be led by LOGANEnergy and supported by the Stennis Facilities Management and Planning Office, Plug Power and Energy Signature Associates.

Stennis Visitor's Center Mars Habitat

Figure 1, Proposed Site Overview

SITE PROPOSAL:
In February 2003, Sam Logan of LOGANEnergy contacted Mr. Bob Heitzman, Director of Facilities Management, about the possibility of hosting a CERL FY'03 PEM demonstration unit at the visitor's center. Since Mr. Heitzman had been involved with the earlier Stennis PC25 Demonstration Program, he responded favorably to the opportunity. Figure 1, at left, is a photo of the Visitor's Center.

SITE AWARD:
In June of 2003, LOGAN submitted NASA Stennis Visitor's Center as a candidate site for the FY'03 PEM Program. However, in July of 2003, CERL indicated that it would prefer to include Stennis with funds left over from the FY'01 PEM Program, and in August 2003, LOGAN received a contract to proceed with the Stennis PEM demonstration project.

KICK-OFF MEETING:
In December 2003, Stennis hosted a project kick-off meeting with representatives of CERL and LOGAN. After reviewing several possible locations at visitor's center, the group consensus favored selecting the SE corner of the restaurant/museum building pictured at right. This site provides great visibility for the project as it is situated adjacent to many other NASA displays. Electrical and Thermal interfaces are very convenient to the site. At right, Frank Holcomb, from CERL is standing on the pad site proposed at the meeting.

Figure 2, View of Proposed FC Pad Location

SITE MODIFICATION

Subsequent to the Kick-off meeting, Stennis advised LOGAN that they preferred to move the fuel cell installation site over to the Mars Habitat display on the North side of the visitor's center.

Mars Habitat

The Mars Habitat seen at left, and in the photo above, provides visitors with an experience of life aboard a home for future space explorers.

Figure 3, Fuel Cell Installation Site Relocation

Notwithstanding the site change, LOGAN will proceed with a similar installation plan that covers the entire scope of the plan envisioned for the original site.

SITE COMMUNICATIONS PACKAGE

Connected Energy Corp.

Following is the drawing of Connected Energy equipment necessary to commission Plug Power fuel cell genset sites in order to communicate with a remote and central data center securely via the Internet. One CENTRYWCC communicates with the Plug Power controller, and another CENTRYWCC is dedicated to interface with the site meters and sensors via CENTRYPIA. The CENTRYPIA allows communication with multiple pulse or analog inputs. The VPN router at the site encrypts the traffic between the site and the data center to make a very secure connection, similar to what banks use to send financial information over the Internet. The modem is optional. If the site allows for direct network access, no modem is necessary (see cost reduction discussion following). Other modems can be used at sites where access or cost drives alternative communication strategies to DSL.

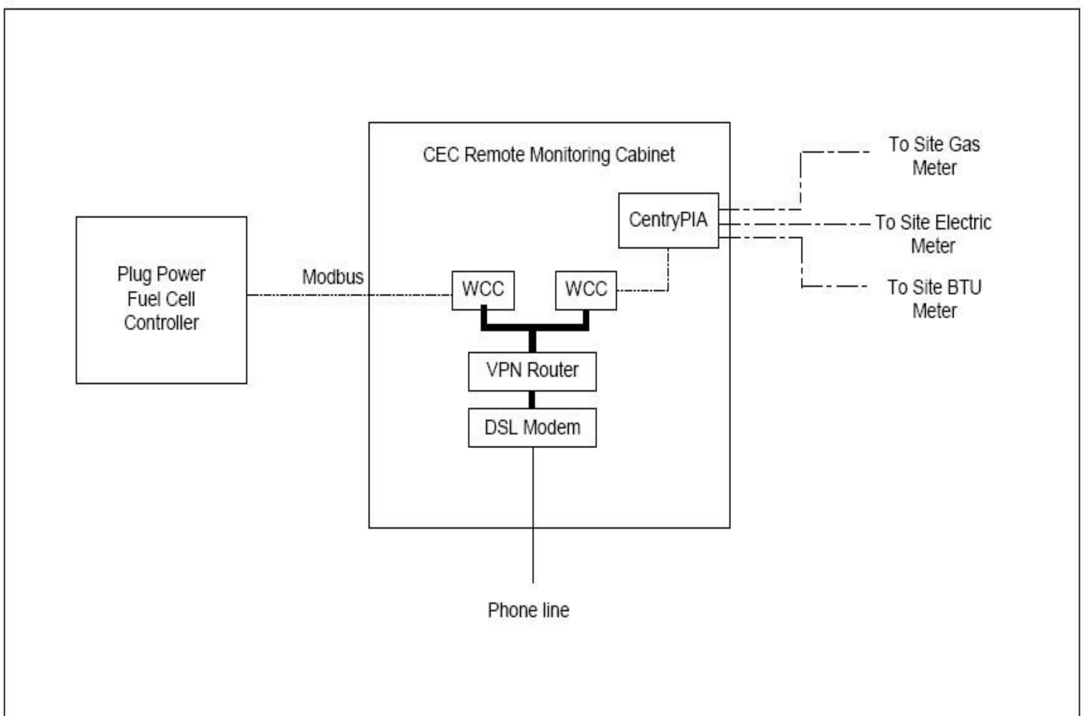


Figure 4, Site Communications

Installation Line Diagram

Stennis Visitor's Center PEM Installation Line Diagram

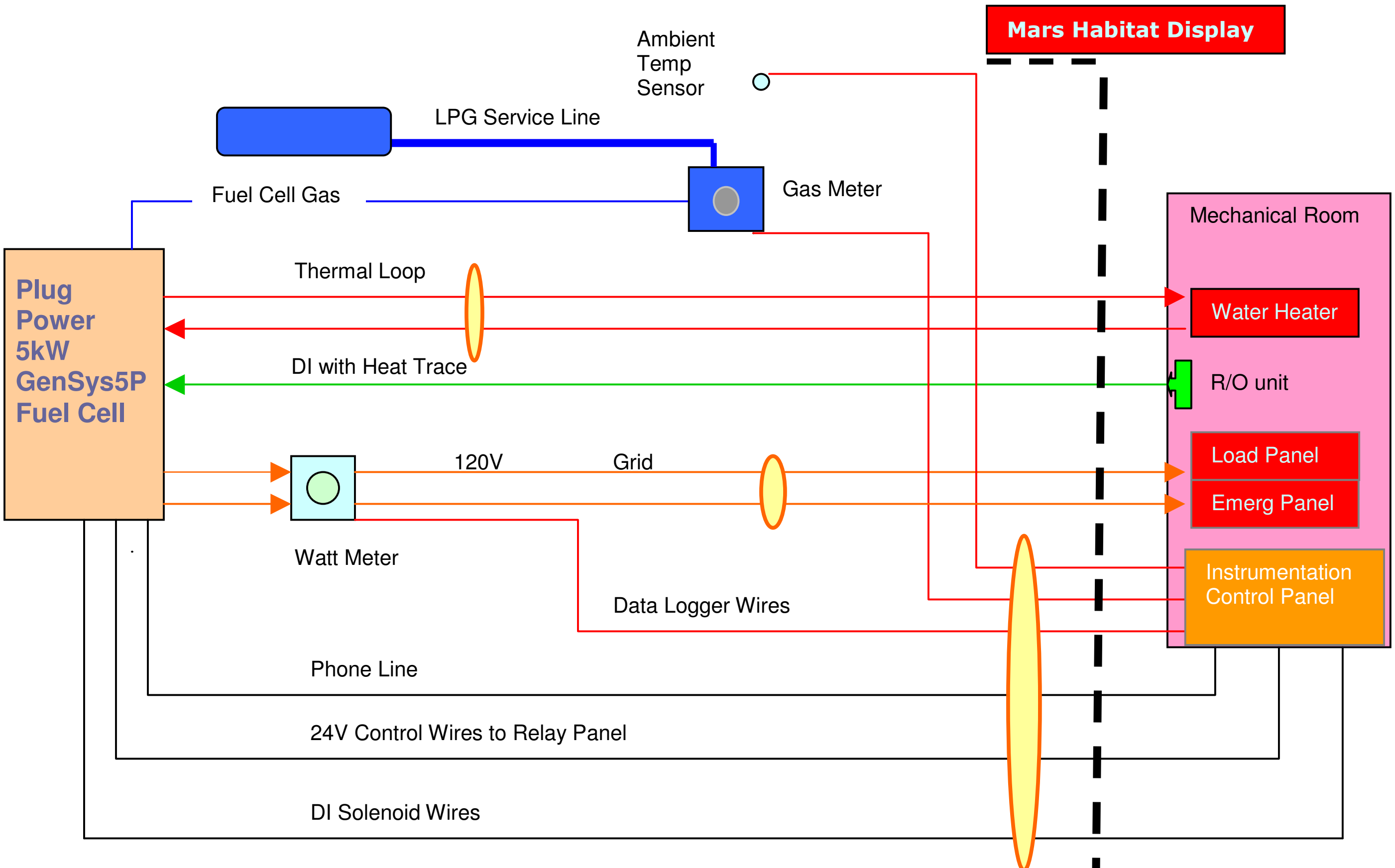
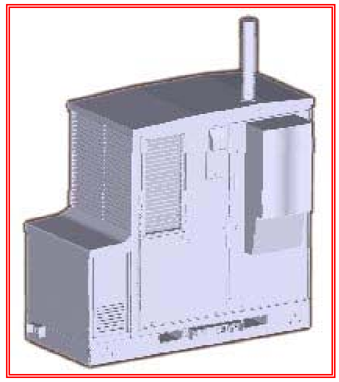


Figure 5, Line Diagram

GenSys5P Product Specifications

Plug Power Fuel Cell System

The GenSys5P is a 5kWAC on-site power generation system fueled by natural gas. Designed to be connected to the existing power grid, the 5P is a clean and efficient source of power that uses LP Gas as its fuel.



Specifications

Physical	Size (L X W X H):	84 1/2" X 32" X 681/4"
Performance	Power rating:__________	5kW continuous
	Power set points:__________	2.5kW, 4kW, 5kW
	Voltage:__________	120/240 VAC @ 60Hz
	Power Quality: __________	IEEE 519
	Emissions:__________	NO_X < 5ppm
		SO_X < 1ppm
		Noise < 70 dBa @ 1meter
Operating Conditions	Temperature:__________	0°F to 104°F
	Elevation:__________	0 to 750 feet
	Installation:__________	Outdoor/CHP
	Electrical Connection:__________	GC/GI
	Fuel:__________	Natural Gas
Certifications	Power Generation:__________	CSA International
	Power Conditioning:__________	UL
	Electromagnetic Compliance:	FCC Class B

Dimensions

Length__________	84 inches
Width__________	32 inches
Height__________	68 ¼ inches

Operating Requirements

Fuel Type__________	LP Gas
Temperature__________	0 degrees F to 104 degrees F

Outputs

Power Output __________	5kW
Voltage __________	120/240 VAC @ 60Hz
Noise __________	< 70 dBA@ 1 meter

Certifications

CSA International__________	Fuel Cell System
UL1741__________	Power Conditioning Module
IEEE P14741__________	Grid Parallel Generation

Figure 6, Product Specifications

Installation Application

Figure 5, above, describes a one line diagram of the planned Stennis Visitor's Center Mars Habitat PEM fuel cell installation. The diagram illustrates utility and control interfaces including, LP Gas, power, water and instrumentation devices that will be installed in the equipment room of the habitat building. Figure 6, above, lists the specifications of the Plug Power GenSys5p LP Gas PEM technology demonstration fuel cell chosen for this site.

The electrical conduit will run between the facility load panels and the fuel cell are estimated to be 25 feet. The Reverse Osmosis/DI water tubing run that will provide filtered process water to the power plant will be approximately 25 feet distance, and the thermal recovery piping runs between the fuel cell and the hot water heater in the Habitat building are also approximately 25 feet. Data storage, retrieval, and Web interface will be accomplished with a Remote Terminal Unit (RTU) seen in figure Figure 5, above.

The fuel cell inverter has a power output of 110/120 VAC at 60 Hz, matching the building distribution panel in the equipment room of the habitat building with its connected loads at 110/120 VAC. The installation will include both a grid parallel and a grid independent configuration. The unit will provide stand-by power to a new critical load panel that will serve routine facility building loads. A two-pole wattmeter will monitor both the grid parallel and grid independent conductors to record fuel cell power distribution to both the existing panel and the new critical load panel.

LOGAN will connect the fuel cell gas piping to a new LP Gas tank to be furnished by Stennis, and install a gas meter to calculate fuel cell usage as indicated in Figure 5, above. A regulator at the fuel cell gas inlet will maintain the correct operating pressure at 14 inches water column.

A phone line connection to the fuel cell modem will provide communications with Plug Power and LOGAN customer support functions.

The installation will proceed in a manner that minimizes inconvenience to visitors and employees at the center.

Permitting

LOGAN will work closely with the NASA Stennis Environmental Departments to insure the installation satisfies all environmental and safety requirements.

Start-up and Commissioning

The initial start is planned for late February 2004. Prior to starting the unit the items covered in Figure 7, below, are to be completed. LOGAN's fuel cell systems technician will continue to test and monitor the unit in accordance with the factory recommended procedures to insure completion of the items listed in Figure 8, below. Operations testing and tuning of the fuel cell's electrical and mechanical systems will continue to insure smooth and reliable performance. It is anticipated that the unit will be declared operational by March 15, 2004.

Service incidents and facility calls will be reported on the sample Service Call Report form listed below as Figure 9.

An Economic Analysis of the Stennis Space Center project appears in Figure 10 below. An installation safety plan appears below in Figure 13.

Installation Check List

TASK	SIGN	DATE	TIME(hrs)
Batteries Installed			
Stack Installed			
Stack Coolant Installed			
Air Purged from Stack Coolant			
Radiator Coolant Installed			
Air Purged from Radiator Coolant			
J3 Cable Installed			
J3 Cable Wiring Tested			
Inverter Power Cable Installed			
Inverter Power Polarity Correct			
RS 232 /Modem Cable Installed			
DI Solenoid Cable Installed with Diode			
Natural Gas Pipe Installed			
DI Water / Heat Trace Installed			
Drain Tubing Installed			

Figure 7, Installation Check List

Commissioning Check List

TASK	SIGN	DATE	TIME (hrs)
Controls Powered Up and Communication OK			
SARC Name Correct			
Start-Up Initiated			
Coolant Leak Checked			
Flammable Gas Leak Checked			
Data Logging to Central Computer			
System Run for 8 Hours with No Failures			

Figure 8, Commissioning Check List

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Service Call Report

SERVICE CALL REPORT

System Serial #:______________________________

SYSTEM INFORMATION

Date:____________________________________

Purpose of Service Call ☐Repair ☐Maintenance ☐ECN (Check all that apply)

	Date	Time
Date/Time shutdown	____________________	____________________

MAINTENANCE / REPAIR INFORMATION

Service Tech Name: ______________________________

Travel Man-hours: ______________________________

Troubleshooting Man-hrs: ______________________________

Repair Man-hours: ______________________________

Spare Part Delay Time: ______________________________

Work Performed: ______________________________

____

Technician ______________________________

Comments: ______________________________

____

____

FAILURE REPORT SUMMARY

Date	Description of Problem	Rpt #	Initials

Figure 9, Service Call Report

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FY' 02 RESSDEM
Stennis PEM Fuel Cell Economic Analysis

Estimated Project Utility Rates	
1) Water (per 1,000 gallons)	$1.69
2) Electricity (per KWH)	$0.0450
3) Natural gas (per MCF)	$6.80

Estimated First Cost	
Plug Power 5 kW SU-1	*$65,000*
Shipping	*$1,800*
Installation electrical	*$1,250*
Installation mechanical	*$3,200*
Watt Meter, Instrumentation	*$3,150*
Site Prep, labor materials	*$925*
Technical Supervision	*$8,500*
Total	***$83,825***

Assume Five Year Simple Payback **$16,765**

Forcast Operating Expenses	**Volume**	**$/Hr**	**$/ Yr**
Natural Gas			
Mcf/hr @ 2.5kW	*0.032838*	*$0.22*	*$1,760*
Water			
Gals/Yr	*4918*		*$8.31*

Add Total Annual Operating Costs	**$1,769**
Total Annual Costs (Ammortization + Expenses)	**$18,534**

Economic Summary		
Forcast Annual kWH	*19710*	
Annual Cost of Operating Power Plant	*$0.0897*	kWH
Credit Annual Thermal Recovery	*-0.016489*	kWH
Project Net Operating Cost	*$0.0733*	kWH
Ammount Available for Financing	*($0.0283)*	kWH
Add 5 Yr Ammortization Cost / kWH	*$0.8506*	kWH

Current Demo Program Cost Assuming 5 Yr Simple Payback **$0.9403 kWH**

***NOTE**Does not include allowance for cell stack life cycle costs or service over 5 year economic senario*

Figure 10, Economic Analysis

Project Contacts

Stennis PEM Fuel Cell Demonstration Program

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Plug Power Project Engineer
Brian Davenport
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brian_davenport@plugpower.com

Figure 11, Project Contacts

Site Location

Stennis Space Center is located in South Mississippi on I-10 at Exit 2 approximately 48 miles west of Biloxi and 45 miles east of New Orleans.

John C. Stennis Space Center
Bldg 2204
Receiving
Stennis Space Center, Mississippi 39529

Figure 12, Site Location

Installation Safety Plan

Project Description	Activity Date
Stennis Space Ctr Fuel Cell Demonstration Project...Electrical and Mechanical Installation and Thermal integration of Plug Power GenSys5C 5kW PEM Fuel Cell Power Plant .	Feburary/March 2004

Installation Site	Project Manager	Prepared By
John C Stennis Space Ctr, Bldg 2204 Receiving Stennis Space Ctr, Mississippi 39529	LOGANEnergy Corp. 1080 Holcomb Br Rd 100 Roswell Summit, Suite 175, Roswell, GA 30076	Samuel Logan, Jr. **Date** 01/15/04

Project Personnel

Project Manager	LOGAN Project Manager/Representative	Emergency Medical Response
Lladro Sylvester (228) 688-2956	**Name** Keith Williams (770) 331-0833	**Covington Region Medical Center**

Project Contractors	Other Personnel	Specialized Equipment for Tasks
Plug Power Brian Davenport (518) 727-4553	Col Harry McCarthy 678-283-6608	Fork Truck, Thermal Welder, Power Drill, Various Power Tools

Installation /Construction

Tasks	Perils	Mitigation
1. Hand Trench 50 feet 1/2" NG Line	Cut/damage other buried utilities, conduit, lines	Locate and Mark buried utilities before trenching.
2. Hand trench 150" water line.	Cut/damage other buried utilities, conduit, lines	Practice correct tie-in techniques, use trained personnel.
3. Offload 2,200 PEM Fuel Cell	Damage Equipment, harm/injure personnel.	Use trained equipment operators with trained observers.
4. Electrical/Mechanical Installation	Electric Shock to personnel. Injury or harm working with power tools.	Use "LOTO" procedures; avoid working "HOT" circuits Use trained personnel on all installation tasks.
5. Initial Start of Equipment	Damage Equipment, harm/injure personnel.	Use factory trained personnel, follow procedures.
6. Maintain General Site Conditions	Unkempt Site...Danger to residents and visitors.	Remove loose materials, tools, police site at end of each day. Place yellow caution ribbon around installation/work areas.
7. Maintain Safe Work Environment	Injury, loss of equipment, materials, customer dissatisfaction, loss of time and money.	Manager's Representative to encourage safe practices by all contractor personnel; critique unsafe practices; and lead by example.
8. Personnel Safety	Head, hand and foot injury.	Construction/installation crews shall wear appropriate personal protective gear while performing job site tasks.

Figure 13, Safety Plan